

06/30/00

07-03-00

A

Please type a plus sign (+) inside this box → ☒

PTO/SB/05 (4/98)

Approved for use through 09/30/2000. OMB 0651-0032  
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No. **24760A**

First Inventor or Application Identifier **Andrew B. Woodside**

Title **Composites Comprising Fibers Dispersed**

Express Mail Label No. **EL547942765US**

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ \* Fee Transmittal Form (e.g., PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2. ☒ Specification [Total Pages **37**]  
(preferred arrangement set forth below)
- Descriptive title of the Invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the Invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets **1**]
4. Oath or Declaration [Total Pages **1**]

- a. ☐ Newly executed (original or copy)
- b. ☐ Copy from a prior application (37 C.F.R. § 1.63(d))  
(for continuation/divisional with Box 16 completed)
- i. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).

\* NOTE FOR ITEMS 1 & 13: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

16. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment:

☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP)

of prior application No. \_\_\_\_\_

Prior application Information: Examiner \_\_\_\_\_

Group / Art Unit: \_\_\_\_\_

For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 4b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

## 17. CORRESPONDENCE ADDRESS

☒ Customer Number or Bar Code Label

22889

(Insert Customer No. or Attach bar code label here)

or ☐ Correspondence address below

|         |           |          |  |
|---------|-----------|----------|--|
| Name    |           |          |  |
| Address |           |          |  |
| City    | State     | Zip Code |  |
| Country | Telephone | Fax      |  |

Name (Print/Type)

Anthony Chi

Registration No. (Attorney/Agent)

41,479

Signature

Anthony Chi 06/30/00

Date

Burden Hour Statement: This form is estimated to take 12 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

**COMPOSITES COMPRISING FIBERS DISPERSED IN A POLYMER  
MATRIX HAVING IMPROVED SHIELDING WITH LOWER AMOUNTS OF  
CONDUCTIVE FIBER**

**5    Field of the Invention**

The present invention relates to composites useful for shielding electromagnetic radiation and their manufacture. In general, the composites of the present invention comprise conductive fibers which are highly dispersed in a polymer matrix. The invention also relates to pellets and their manufacture. Such pellets are useful in the manufacture of composites comprising highly dispersed conductive fibers in a polymer matrix.

**Background of the Invention**

The increased usage of electronic equipment such as computers and other digital devices has lead to a concern for the hazards associated with electromagnetic radiation such as radar waves, microwaves, and electromagnetic radiation produced by electronic circuits. Because of these concerns, electromagnetic shielded composites have been developed to: 1) protect the user of an electronic device, 2) protect an electronic device, and 3) protect surrounding electronic devices. As the electronic industry grows there is an increasing need for improved electromagnetic shielded materials which may be incorporated into electronic products.

Plastic articles formed with electrically conductive materials are particularly convenient as compared to traditional metal materials because they are light weight, easily produced using injection molding techniques, and of low cost. Typically these electrically conductive materials are composites of plastics and conductive fibers.

Various conventional techniques have been employed when incorporating electrically conductive fibers into a polymer matrix to make electromagnetic shielded composites. A drawback to these techniques is their inability to provide for adequate dispersions of conductive fibers within the composites. A technique which yields poor dispersions of conductive fibers in a composite requires the use of larger amounts of fibers in order to obtain effective electromagnetic shielding. To solve this problem, conventional techniques have employed several mechanical means to intimately mix conductive fibers a polymer to make a composite product. Unfortunately, the mechanical mixing of conductive fibers with a polymer

is stressful and causes damage to the fibers such as fracture or breakage. These damaged fibers impart reduced electromagnetic shielding properties due to their reduced ability to conduct electricity through the composite article.

An example of a basic technique for making an electromagnetic shielded composite involves heating a thermoplastic to a molten temperature and then kneading in the conductive powders fibers. Unfortunately, when kneading conductive fibers with a molten thermoplastic, the fibers are often broken due to the cutting action by the kneading screw and by the shearing of the resin. These fibers are broken into smaller and smaller segments such that the resulting composite article contains only shorter length broken fibers. Such shortened fibers impart reduced electromagnetic shielding properties to the composite article due to their reduced ability to conduct electricity through the composite article. Composite articles formed with broken fibers require the use of higher amounts fiber and may lead to embrittlement of the composite article thus formed. Additionally, operators working directly with the cut fibers and powders can experience pain or itchiness in handling the materials.

To avoid the problems with directly mixing in cut fibers, attempts have been made to provide electromagnetic shielding plastic compound pellets by impregnating conductive fibers with a polymer and then cutting the impregnated fiber into pellet form. An example of such a process involves the use of continuous lengths of filaments which are passed through a bath containing a molten resin whereby such filaments become impregnated with the polymer.

Once the filaments are impregnated they are continuously withdrawn from the bath, commingled either before or after passage through a heat source and cooled to solidify the molten resin around the fibers. These impregnated fibers are then cut to form pellets which are then formed into composite articles. Another example of an impregnation technique involves the use of a conductive tow comprised of a plurality of strands. The tow is mechanically splayed allowing for the impregnation of a polymer between the strands and then the strands subsequently gathered together into an impregnated tow which is cooled and chopped into pellets. There are various disadvantages to these impregnation techniques. One disadvantage is that impregnation techniques are relatively slow and cumbersome. Additionally, impregnation techniques often do not provide adequate integration of polymer and fiber. Impregnated fibers often fray when cut into pellets and can become separated from

the resin. When consolidated into a composite, pellets made by impregnation techniques often provide an inadequate dispersion of fibers and poor electromagnetic shielded ability. It is believed this is due, at least in part, to the inadequate integration of polymer and fiber resulting from impregnation techniques.

5 A possible solution to the problems associated with impregnation techniques is to encase or coat fibers with a polymer sheath. For example, U.S. Pat. No. 4,530,779 to Mayama et al., discloses initially coating a strand of fibers with a coupling agent and subsequently coating the strand with a polymer. The coated strand is then chopped into pellets. Other attempts at forming electromagnetic shielded articles have passed electrically  
10 conductive fiber strands through a bath of a polymeric material to first impregnate the fibers. These impregnated strands are then encased with a second polymeric material as exemplified by U.S. Pat. No. 4,664,971 and U.S. Pat. No. 5,397,608 both to Soens. The encased strands are then chopped into pellets. A disadvantage of the aforementioned methods exemplified by Mayama et al. and Soens is that these methods produce pellets,  
15 which by themselves, are not adequate to form an electromagnetic shielded composite. Additional polymer material must be added to the pellets resulting in an additional mixing step which often causes mechanical damage such as fracture or breakage of conductive fibers. Mechanical damage to the conductive fibers results in a composite with poor electromagnetic shielding. Another method, as described in U.S. Pat. No. 4,960,642 to Kosunga et al.,  
20 discloses impregnating conductive fibers with an oligomer and encasing the resulting impregnated bundled fibers in a polymer. The encased bundled fibers are then chopped into pellets. A major drawback to the method of Kosunga et al. is that the fibers must be impregnated under pressure.

Accordingly, there is a long felt need in the art for a method which provides an  
25 adequate dispersion of electrically conductive fibers in a polymer matrix to make an electrically shielded composite. The present invention provides for such a method without any of the disadvantages identified in conventional methods as exemplified above. Unlike conventional methods, the present invention provides for a composite with improved electrical shielding properties and avoids undesirable mechanical damage to conductive fibers. The  
30 present invention also provides for pellets, which by themselves, may be consolidated into an

electrically shielded composite and avoids the undesirable step of mixing additional polymer material to the pellets. Furthermore, the present invention avoids the complex and/or cumbersome impregnation techniques found in conventional methods.

## 5 Summary of the Invention

An object of this invention is electromagnetic shielded composites and their manufacture where the composites comprise highly dispersed conductive fibers in a polymer matrix. Another object of this invention is pellets, which by themselves, are useful in forming electromagnetic shielded composites comprising highly dispersed conductive fibers. The pellets comprise a conductive fiber core, a chemical treatment, and a sheathing polymer.

According to the invention, pellets are made by subjecting an electrically conductive strand to a chemical treatment thereby creating a chemically treated strand. The chemically treated strand is then encased in a polymer sheath thereby creating a sheathed strand. The sheathed strand is then chopped into pellets.

The sheathed strand is then chopped into pellets, which without any need of additional polymer, may be consolidated into an electromagnetic shielding composite. The pellets preferably have an average diameter of from 2mm to 12mm.

The electrically conductive strand comprises a plurality of gathered fibers which are in turn composed of any material which is electrically conductive. The gathered fibers may be composed entirely of metal, metal alloys, or an electrically conductive polymer. The gathered fibers may also comprise organic or inorganic fibers which have been coated, plated, or otherwise treated so that the fibers are electrically conductive. Preferably, the conductive strand comprises at least 40 gathered fibers.

At most the final polymer sheathed pellet should comprise no more than 8 wt % of the chemical treated and preferably no more than 5 wt %. Amounts greater than 8 wt. % may lead to problems such as off gassing and drool during injection molding. Preferably, the chemical treatment comprises an organic material in liquid form (aqueous or preferably non-aqueous) having a viscosity not higher than 1500 cps, preferably not higher than 800 cps, and more preferably not higher than 200 cps, at a temperature range of 80° - 180° C. The organic material of the chemical treatment should also be compatible with the polymer sheath.

Preferably, the chemical treatment comprises an organic monomer or oligomer have a degree of polymerization less than 20. Examples of suitable organic materials which comprise the chemical treatment of this invention include: bisphenol A, propoxylated bisphenol A, diphenyl ether, diphenyl sulfone, stilbene, diglycidyl ether of bisphenol A, triglycidylisocyanurate, citric acid, pentaerythritol, dicyandiimide, 4,4'-sulfonyldianiline, 3,3'-sulfonyldianiline, stearate-capped propyleneglycol fumarate oligomer, butoxyethylstearate, ethylene carbonate, sorbitan monostearate, hydrogenated vegetable oil.

The chemical treatment may be applied by conventional means known in the art. Preferably a strand of conductive fibers is towed across a bath comprising the chemical treatment which is heated to between 80-180°C to obtain a viscosity not higher than 1500 cps, preferably not higher than 800 cps, and more preferably not higher than 200 cps. Preferably, the strand is first heated before introduction to the bath in order to promote the wicking of the chemical treatment into the interstices thereof. Although not preferable, the chemical treatment may be applied using the methods set forth in U.S. Pat. Application No. 08/695,504 and U.S. Pat. Application No. 08/695,909 both of which are hereby fully incorporated by reference. Accordingly, the chemical treatment may be applied to individual fibers which are then gathered to form an impregnated strand which is subsequently encased in a sheathing polymer.

The polymer sheath may comprise any polymer such as thermoset or thermoplastic polymers. If the chemically treated strand is encased in a thermoset polymer, the thermoset polymer is left uncured or partially cured. The thermoset polymer should be convertible by heat or light, alone or in combination with catalysts, accelerators, cross-linking agents, etc., to form the electronic shielded composites of the invention. By way of illustration, some of the polymers useful as a polymer sheath of the invention include: polyesters, polyethers, polycarbonates, epoxies, phenolics, epoxy-novolacs, epoxy-polyurethanes, urea-type resins, phenol-formaldehyde resins, melamine resins, melamine thiourea resins, urea-aldehyde resins, alkyd resins, polysulfide resins, vinyl organic prepolymers, multifunctional vinyl ethers, cyclic ethers, cyclic esters, polycarbonate-coesters, polycarbonate-co-silicones, polyetheresters, polyimides, bismaleimides, polyamides, polyetherimides, polyamideimides, polyetherimides, and polyvinyl chlorides. The polymeric material may be present alone or in

combination with copolymers, and compatible polymeric blends may also be used. In short, any conventional polymeric material may be selected and the particular polymer chosen is generally not critical to the invention. Preferred polymers are polycarbonate, acrylonitrile butadiene styrene, polycarbonate acrylonitrile butadiene styrene copolymer, polybutylene terephthalate, styrene, polypropylene, and nylon

The sheathing polymer is applied to a chemically treated strand so that the strand is thoroughly coated with the polymer resulting in a material comprising a core of chemically treated conductive strand encased in a polymer sheath of relatively uniform thickness. Conventional wire coating methods may be employed to encase the chemically treated strands of this invention. Such methods include passing a chemically treated strand into a single hole extrusion die which is supplied with molten polymer to encase the strand. Preferable wire coating methods are those described in U.S. Pat. Application No. 08/695,504 and U.S. Pat. Application No. 08/695,909 both of which are hereby fully incorporated by reference.

Once a chemically treated strand is encased with a polymer sheath, it may be chopped into pellets which may be consolidated into a electromagnetic shielded composite without the need of any additional polymer or other ingredients. Any conventional chopper may be used with the present invention.

## **Brief Description of the Drawing**

Figure 1 shows a comparison of the electromagnetic shielding properties of composites made with conventional methods as compared to composites which may be obtained according to the present invention.

## **Detailed Description of the Invention**

The electromagnetic shielding composites of the present invention contain highly dispersed amounts of conductive fibers within a polymer matrix and generally exhibit greater shielding properties when compared to conventional electromagnetic shielding composites having the same amount and type of conductive fibers. The improved shielding performance with minimized amounts of conductive fibers is exemplified by Figure 1. The x-axis of Figure

1 represents the amount of conductive fibers by wt. % of a composite while the y-axis represents shielding performance of a composite as measured in decibels by ASTM D4935. Plotted on the graph of Figure 1 are two comparative samples of electromagnetic shielded composites made by conventional means. The comparative samples are made according to the methods outlined under the heading "Comparative Sample" as Examples 32-33 below. A linear fit line is drawn through the plotted comparative samples which includes the point 0,0. Also plotted on the graph of Figure 1 are two inventive samples of electromagnetic shielded composites made in accordance with the present invention. The inventive samples are made according to the methods outlined under the heading "Inventive Sample" as Examples 30-31 below. As can be seen in the graph of Figure 1, composites made in accordance with the present invention generally show increased shielding properties at any given fiber content.

In one embodiment of the invention, the pellets useful for making the electromagnetic shielded composites of the present invention are made in accordance the method described below. A conductive fiber strand is placed on a tensioning creel device, such as Unwind Tension Compensator Model No. 800C012 from Compensating Tension Controls Inc (CTC). The fiber strand then passes, under constant tension, through a tube furnace, such as a Type 55035A available from Lindberg of 304 Hart St., Wauwatosa, Wisconsin. The tube furnace is typically operated at a temperature of 800° F (427°C) which imparts sufficient thermal energy to the surface of the fibers to promote wicking of the chemical treatment onto the individual filaments. The heated fibers are then allowed to pass over a chemical treatment application device which may be fabricated by machining an 1/8" (3.175) wide groove into a 6" (15.24cm) by 1/2" (1.27cm) by 1" (2.54cm) piece of brass bar stock. Generally, the groove depth varies from 1/2" (1.27cm) deep on the ends to 1/4" (0.63cm) deep in the middle. Typically, at the bottom of the groove are two holes through which the chemical treatment is pumped. One suitable pump is a Zenith model HPB, delivering 0.297 cc per revolution and is available from the Zenith Pumps Division of the Parker Hannifin Corporation, Sanford, North Carolina. The chemical treatment can be delivered to the applicator via metal piping and can be pumped from a heated reservoir, typically a one-gallon metal paint can on a laboratory hot plate. The chemically treated fiber strand then passes into a single hole extrusion coating die which is supplied with molten thermoplastic, for example, by a model KN-200, 2" (5.08cm) screw, 100



rpm max extruder available from Killion of Cedar Grove, New Jersey. Thermoplastic resin supplied to the extruder is then dried preferably using a model N-2 resin-drying oven available from IMS Company of Auburn, Ohio. Once chemically treated fiber strand is encapsulated with molten thermoplastic, it exits the extrusion coating die and immediately enters a 12'

(3.66m) long cooling trough filled with water. The water in this bath is maintained at room temperature or lower with, for example, a model R100 chiller unit available from Haskris of Elk Grove Village, Illinois. As the encased strand exits the cooling trough excess water is removed by allowing the thermoplastic encased tow to pass through an air knife, such as a model HV-1 air knife from Bertyn of Worcester, Massachusetts. Pellets are then formed by chopping the wire coated material into discrete 4 millimeter lengths using, for example, a Conair model 204 T chopper available from Conair / Jetro of Bay City, Michigan. The pellets are then dried as above before being injection molded into test specimens or finished composite parts.

Suitable conductive fibers for the present invention are available from a number of suppliers. Stainless steel fibers may be obtained from Bekaert Corporation/Bekaert Fibre Technologies Marietta, Georgia, product numbers Beki-Shield BU08/5000 CR E, and Beki-Shield BU08/12000 CR E. One type of electroplated metal-coated carbon fibers may be obtained from Composite Material, L.L.C., Mamaroneck, New York, product numbers, PPO-1200-NiCuNi, PPO-1200-NiCu, and PPO-1200-Ni. Another type of electroplated metal-coated carbon fiber may be obtained from Toho Carbon Fiber, Inc. Irvine, California, product number, G30-500 12K A203 MC. Another type of metal-coated carbon fibers may be obtained from Inco Special Products Wyckoff, New Jersey, Product Numbers, INCOFIBER® 12K20 Nickel Coated Carbon Fiber, and INCOFIBER® 12K50 Nickel Coated Carbon Fiber. Carbon fiber is available as Besfight G30-500 HTA 7C NS01 from Toho Carbon Fiber, Inc. Irvine, California or as Grafil 34-700 12K from Grafil Inc. Sacramento, Ca.

Suitable conductive strands for the present invention may be made by conventional methods known in the art. For example, a tow consisting of forty filaments of copper wire was prepared from ten spools of awg-41 bare copper wire available from Elektrisola of Boscawen, New Hampshire, by collecting the ten individual wires from the ten spools into a single tow of ten filaments by winding them onto a single spool. Likewise, four of these tows containing ten

filaments each were then collected by winding them together into a single forty-filament tow on a single spool.

EXAMPLES:

Testing for electromagnetic interference (EMI) shielding was accomplished according to ASTM D 4935. This requires a test fixture for holding the four inch diameter, injection molded test specimens. A suitable ASTM D4935 specimen holder is commercially available from Electro-Metrics, Inc. of Johnstown, New York. A suitable analyzer is HP RF Vector Network Analyzer, commercially available from Agilent Technologies of Englewood, Colorado. This provides an average shielding effectiveness number for the frequency range of 30 Mhz - 1.2 Ghz. Surface conductivity was measured using the method described in ASTM D257.

The stearate-capped propyleneglycol fumarate oligomer (PGF-ST) chemical treatment used in the examples below was prepared as follows: A ten gallon stainless steel reactor was charged with 8.885 kg of propylene glycol (Ashland Chemical Company, Columbus, Ohio), 8.469 kg of fumaric acid (Huntsman Specialty Chemical), 13.84 Kg of stearic acid (Aldrich Chemical), and 31.19 g of dibutyl tin oxide (DBTO) catalyst, available from Elf Atochem of Philadelphia, Pennsylvania under the trade name Fascat 4201. For stability, 3.51 g, 112.5 ppm of toluhydroquinone (THQ) available from Aldrich Chemical of Milwaukee, Wisconsin is added to the reactor. The molar ratio of the charge was 4:3:2 propyleneglycol (PG) to fumaric acid (FA) to stearic acid (ST) with 20% additional propylene glycol added to compensate for glycol losses from the distillation column over the course of the reaction. The mixture, under a nitrogen atmosphere, was heated to 390 °F (199 °C) for five hours. The endpoint of the reaction was determined by the viscosity of the stearate-capped, PG-fumarate product which was in the range of 150 -190 cps at 50 °C as determined by an ICI cone and plate viscometer. The acid value at the reaction end point was typically observed to be within the range of 0 – 2 meq KOH/g resin.

Example 1

To a one gallon metal paint can was added 2 Kg of propoxylated bisphenol A. This chemical treatment was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal

equilibrium, the container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the bis-A-diol had a viscosity of 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 5.63 grams per minute; extruder 277.48 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.42 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.69 Kg of chemical treatment and the mixture was then encapsulated with 83.24 Kg of thermoplastic resin affording 97.93 Kg of composite pellets having the composition of 13.27 % Ni Cu Ni fiber, 1.73% bis-A-diol chemical treatment, and 85% PC-ABS, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 48db as measured by the ASTM D4935 test.

#### Example 2

To a one gallon metal paint can was added 5 Kg of PGF-ST. This chemical treatment was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the polyester oligomer had a viscosity of 150 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 16.5 grams per minute; extruder 357.9 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.42 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 4.6 Kg of chemical treatment and the mixture was then encapsulated with 99.7 Kg of thermoplastic resin affording 117.3 Kg of composite pellets having the composition of 11.1%

Ni Cu Ni fiber, 3.9% PGF-ST chemical treatment, and 85% PC-ABS, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 22db as measured by the ASTM D4935 test.

### Example 3

To a one gallon metal paint can was added 6 Kg of ethylene carbonate. This chemical treatment was not heated. The container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at room temperature, 70 °F (21.1 °C). At this temperature, the monomer had a viscosity of 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 19 grams per minute; extruder 376 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.55 grams per meter and was not heated. Under these conditions, 13 Kg of conductive fiber was coated with 5.2 Kg of chemical treatment and the mixture was then encapsulated with 103.3 Kg of thermoplastic resin affording 121.5 Kg of composite pellets having the composition of 10.7% Ni Cu Ni fiber, 4.3% ethylene carbonate chemical treatment, and 85% PC-ABS, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath but the quality was not as good as the above two examples. Occasionally some loose filaments would be observed among the bulk pellets. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 2mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 49db as measured by the ASTM D4935 test.

Example 4

A 4.38 molal solution was prepared by adding 1.5 Kg, 6.57 moles of bisphenol-A to 1.5 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 40 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.25 grams per minute; extruder 271.53 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.37 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% bis-A-diol / bisphenol-A chemical treatment, and 85% PC-ABS, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 75db as measured by the ASTM D4935 test and a surface resistivity of 0.6 – 52 ohm/sq.

Example 5

A 0.19 molal solution was prepared by adding 1.5 Kg, 0.29 moles of sorbitan monostearate to 1.5 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the

temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 40 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.25 grams per minute; extruder 271.53 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.37 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% bis-A-diol / sorbitan monostearate chemical treatment, and 85% PC-ABS, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 75db as measured by the ASTM D4935 test.

#### Example 6

To a one gallon metal paint can was added 4 Kg of castor oil. This chemical treatment was not heated. The container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at room temperature, 70 °F (21.1 °C). At this temperature, the monomer had a viscosity of 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 10 grams per minute; extruder 308 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.45 grams per meter and was not heated. Under these conditions, 13 Kg of conductive fiber was coated with 2.93 Kg of chemical treatment and the mixture was then encapsulated with 90.24 Kg of thermoplastic resin affording 106.17 Kg of composite pellets having the composition of 12.2% Ni Cu Ni fiber, 2.8% castor oil chemical treatment, and 85% polycarbonate, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of

uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath but the quality was not as good as the above two examples. Occasionally some loose filaments would be observed among the bulk pellets. The pellets were injection molded at a melt temperature of 580 °F into a tool at 180 °F (82.2 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 13db as measured by the ASTM D4935 test.

#### Example 7

A 1.30 molal solution was prepared by adding 0.6 Kg, 3.12 moles of citric acid to 2.4 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 3 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 5.75 grams per minute; extruder 250 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.26 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% bis-A-diol / citric acid chemical treatment, and 85% polycarbonate, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 81db as measured by the ASTM D4935 test and a surface resistivity of 0.2 – 93 ohm/sq.

Example 8

A 0.19 molal solution was prepared by adding 1.5 Kg, 0.29 moles of sorbitan monostearate to 1.5 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment

5 mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 40 cps. The process parameters were set as follows: puller = 30.48 meters per

10 minute; Zenith pump = 6.25 grams per minute; extruder 271.53 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.37 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of

15 composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% bis-A-diol / sorbitan monostearate chemical treatment, and 85% polycarbonate, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had

20 conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 82db as measured by the ASTM D4935 test and a surface resistivity of 0.4 – 11.1 ohm/sq.

Example 9

To a one gallon metal paint can was added 3 Kg of sorbitan monostearate. This chemical treatment was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9

30 °C). At this temperature, the sorbitan monostearate had a viscosity of 1 cps. The process



parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 7 grams per minute; extruder 304.1 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.42 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% sorbitan monostearate chemical treatment, and 85% polycarbonate, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 84db as measured by the ASTM D4935 test and a surface resistivity of 0.2 – 1.2 ohm/sq.

#### Example 10

To a one gallon metal paint can was added 4 Kg of mineral oil. This chemical treatment was not heated. The container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at room temperature, 70 °F (21.1 °C). At this temperature, the monomer had a viscosity of less than 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 9.6 grams per minute; extruder 313.2 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.50 grams per meter and was not heated. Under these conditions, 13 Kg of conductive fiber was coated with 2.73 Kg of chemical treatment and the mixture was then encapsulated with 89.15 Kg of thermoplastic resin affording 104.9 Kg of composite pellets having the composition of 12.4% Ni Cu Ni fiber, 2.6% mineral oil chemical treatment, and 85% polybutyleneterephthalate, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and

well centered in the thermoplastic sheath but the quality was not as good as the following two examples. Occasionally some loose filaments would be observed among the bulk pellets. The pellets were injection molded at a melt temperature of 560 °F (293 °C) into a tool at 180 °F (82.2 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 21db as measured by the ASTM D4935 test.

#### Example 11

A 0.19 molal solution was prepared by adding 1.5 Kg, 0.29 moles of sorbitan monostearate to 1.5 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of less than 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.25 grams per minute; extruder 271.53 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.37 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% bis-A-diol / sorbitan monostearate chemical treatment, and 85% polybutyleneterephthalate, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 560 °F (293 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 71db as measured by the ASTM D4935 test and a surface resistivity of 0.9 – 35 ohm/sq.

Example 12

To a one gallon metal paint can was added 3 Kg of butoxyethylstearate. This chemical treatment was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the sorbitan monostearate had a viscosity of less than 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 7 grams per minute; extruder 304.1 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.53 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% butoxyethylstearate chemical treatment, and 85% polybutyleneterephthalate, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 560 °F (293 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 73db as measured by the ASTM D4935 test and a surface resistivity of 4.4 – 999 ohm/sq.

Example 13

To a one gallon metal paint can was added 3 Kg of hydrogenated vegetable oil. This chemical treatment was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the hydrogenated vegetable oil had a viscosity of less than 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump =

6.6 grams per minute; extruder 286.7 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.44 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% hydrogenated vegetable oil chemical treatment, and 85% polybutyleneterephthalate, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 560 °F (293 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 79db as measured by the ASTM D4935 test and a surface resistivity of 1.2 – 41 ohm/sq.

#### Example 14

To a one gallon metal paint can was added 5 Kg of ethylene carbonate. This chemical treatment was not heated. The container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at room temperature, 70 °F (21.1 °C). At this temperature, the monomer had a viscosity of less than 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 17 grams per minute; extruder 365 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.55 grams per meter and was not heated. Under these conditions, 13 Kg of conductive fiber was coated with 4.7 Kg of chemical treatment and the mixture was then encapsulated with 100.1 Kg of thermoplastic resin affording 121.5 Kg of composite pellets having the composition of 11% Ni Cu Ni fiber, 4% ethylene carbonate chemical treatment, and 85% polypropylene, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath but the quality was not as

good as the above Example 13. Occasionally some loose filaments would observed among the bulk pellets The pellets were injection molded at a melt temperature of 535 °F (279 °C) into a tool at 130 °F (54.4 °C). The resulting 4" (10.16 cm) diameter X 2mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 70db as measured by the ASTM D4935 test and a surface resistivity of 5 – 25 ohm/sq.

#### Example 15

A 1.30 molal solution was prepared by adding 0.6 Kg, 3.12 moles of citric acid to 2.4 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 3 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.65 grams per minute; extruder 289 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu with an average yield of 1.45 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% bis-A-diol / citric acid chemical treatment, and 85% polypropylene, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 535 °F (279 °C) into a tool at 130 °F (54.4 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 85db as measured by the ASTM D4935 test and a surface resistivity of 0.6 – 9.6 ohm/sq.

Example 16

A 2.19 molal solution was prepared by adding 0.75 Kg, 3.29 moles of bisphenol-A to 2.25 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 330 °F (165 °C) for three hours. Once at thermal equilibrium,

5 the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of less than 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.65 grams per minute; extruder 289 grams per minute; and chopper = 4 mm chop

10 length. The conductive fiber used was Ni Cu with an average yield of 1.45 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni Cu fiber, 1.96% bis-A-diol / bisphenol-A chemical

15 treatment, and 85% Nylon, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1 mm disk test specimens had conductive fibers well dispersed

20 throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 77db as measured by the ASTM D4935 test and a surface resistivity of 2.9 – 450 ohm/sq.

Example 17

25 To a one gallon metal paint can was added 4 Kg of PGF-ST. This chemical treatment was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the polyester oligomer had a viscosity of 30 cps. The process parameters were

30 set as follows: puller = 30.48 meters per minute; Zenith pump = 13 grams per minute;

extruder 338 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.53 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 3.62 Kg of chemical treatment and the mixture was then encapsulated with 94.2 Kg of thermoplastic resin affording 110.8 Kg of composite pellets having the composition of 11.7% Ni Cu Ni fiber, 3.3% PGF-ST chemical treatment, and 85% ABS, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 490 °F (254.4 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 2mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 68db as measured by the ASTM D4935 test.

15 Example 18

To a one gallon metal paint can was added 5 Kg of PGF-ST. This chemical treatment was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the polyester oligomer had a viscosity of 30 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 16.4 grams per minute; extruder 375 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.63 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of conductive fiber was coated with 4.32 Kg of chemical treatment and the mixture was then encapsulated with 98.1 Kg of thermoplastic resin affording 115.4 Kg of composite pellets having the composition of 11.3% Ni Cu Ni fiber, 3.7% PGF-ST chemical treatment, and 85% polyethyleneterephthalate, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt

temperature of 560 °F (293 °C) into a tool at 180 °F (82.2 °C). The resulting 4" (10.16 cm) diameter X 2mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 82db as measured by the ASTM D4935 test and a surface resistivity of 2 – 5 ohm/sq.

#### Example 19

To a one gallon metal paint can was added 5 Kg of ethylene carbonate. This chemical treatment was not heated. The container with contents was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at room temperature, 70 °F (21.1 °C). At this temperature, the monomer had a viscosity of 1 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 16 grams per minute; extruder 332 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was Ni Cu Ni with an average yield of 1.40 grams per meter and was not heated. Under these conditions, 13 Kg of conductive fiber was coated with 4.9 Kg of chemical treatment and the mixture was then encapsulated with 101.3 Kg of thermoplastic resin affording 119.1 Kg of composite pellets having the composition of 10.9% Ni Cu Ni fiber, 4.1% ethylene carbonate chemical treatment, and 85% HIPS, with the chemically treated, metallized, fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath but the quality was not as good as the above two examples. Occasionally some loose filaments would observed among the bulk pellets The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 2mm disk test specimens had conductive fibers moderately well dispersed throughout the composite. Occasional undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 73db as measured by the ASTM D4935 test and a surface resistivity of 8 – 50 ohm/sq.

#### Example 20

A 4.38 molal solution was prepared by adding 1.5 Kg, 6.57 moles of bisphenol-A to 1.5 Kg of



bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was

5 maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 40 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.75 grams per minute; extruder 293.25 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was stainless steel with an average yield of 1.48 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of

10 conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % stainless steel fiber, 1.96% bis-A-diol / bisphenol-A chemical treatment, and 85% PC-ABS, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and

15 shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 53db as measured by

20 the ASTM D4935 test and a surface resistivity of greater than 20 ohm/sq.

#### Example 21

Using the same chemical treatment and conductive fiber as in Example 20, a sample containing a lower concentration of conductive fiber may be prepared by setting the process

25 parameters as follows: puller = 30.48 meters per minute; Zenith pump = 6.75 grams per minute; extruder 465.75 grams per minute; and chopper = 4 mm chop length. Under these conditions, 8.7 Kg of conductive fiber was coated with 1.31 Kg of chemical treatment and the mixture was then encapsulated with 90.05 Kg of thermoplastic resin affording 100.05 Kg of composite pellets having the composition of 8.7 % stainless steel fiber, 1.3% bis-A-diol /

30 bisphenol-A chemical treatment, and 90% PC-ABS, with the chemically treated metallized

fiber tow comprising 10% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 45db as measured by the ASTM D4935.

#### Example 22

Plated nickel coated carbon conductive fiber, having an average yield of 1.39 grams per meter, was processed as described in Example 20. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.35 grams per minute; extruder 275.87 grams per minute; and chopper = 4 mm chop length. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % Ni-C fiber, 1.96% bis-A-diol / bisphenol-A chemical treatment, and 85% PC-ABS, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 74db as measured by the ASTM D4935 test and a surface resistivity of 1 - 14 ohm/sq.

#### Example 23

Using the same chemical treatment and conductive fiber as in Example 20, a sample containing a lower concentration of conductive fiber may be prepared by setting the process parameters as follows: puller = 30.48 meters per minute; Zenith pump = 6.35 grams per minute; extruder 438.15 grams per minute; and chopper = 4 mm chop length. Under these

conditions, 8.69 Kg of conductive fiber was coated with 1.31 Kg of chemical treatment and the mixture was then encapsulated with 90.05 Kg of thermoplastic resin affording 100.05 Kg of composite pellets having the composition of 8.7 % conductive fiber, 1.3% bis-A-diol / bisphenol-A chemical treatment, and 90% PC-ABS, with the chemically treated metallized fiber tow comprising 10% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 61db as measured by the ASTM D4935.

#### Example 24

Chemical Vapor Deposited (CVD) nickel coated carbon conductive fiber, having an average yield of 2.01 grams per meter, was processed as described in Example 20. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 9.3 grams per minute; extruder 399.69 grams per minute; and chopper = 4 mm chop length. Under these conditions, 13 Kg of conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % CVD-Ni-C fiber, 1.96% bis-A-diol / bisphenol-A chemical treatment, and 85% PC-ABS, with the chemically treated metallized fiber tow comprising 15% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 80db as measured by the ASTM D4935 test and a surface resistivity of 0.3 - 48 ohm/sq.

Example 25

Using the same chemical treatment and conductive fiber as in Example 24, a sample containing a lower concentration of conductive fiber may be prepared by setting the process parameters as follows: puller = 30.48 meters per minute; Zenith pump = 9.2 grams per minute; extruder 634.8 grams per minute; and chopper = 4 mm chop length. Under these conditions, 8.69 Kg of conductive fiber was coated with 1.31 Kg of chemical treatment and the mixture was then encapsulated with 90.05 Kg of thermoplastic resin affording 100.05 Kg of composite pellets having the composition of 8.7 % CVD-Ni-C fiber, 1.3% bis-A-diol / bisphenol-A chemical treatment, and 90% PC-ABS, with the chemically treated metallized fiber tow comprising 10% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 73db as measured by the ASTM D4935.

Example 26

Using the same chemical treatment as in Example 4, and Ni Cu conductive fiber of average yield 1.36 grams per meter, a sample containing a lower concentration of conductive fiber may be prepared by setting the process parameters as follows: puller = 30.48 meters per minute; Zenith pump = 6.2 grams per minute; extruder 427.8 grams per minute; and chopper = 4 mm chop length. Under these conditions, 8.69 Kg of conductive fiber was coated with 1.31 Kg of chemical treatment and the mixture was then encapsulated with 90.05 Kg of thermoplastic resin affording 100.05 Kg of composite pellets having the composition of 8.7 % conductive fiber, 1.3% bis-A-diol / bisphenol-A chemical treatment, and 90% PC-ABS, with the chemically treated metallized fiber tow comprising 10% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm)

diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 71db as measured by the ASTM D4935.

5 Example 27

An experimental tow of 40 copper wire filaments, having an average yield of 1.36 grams per meter, was processed as described in Example 4. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 6.2 grams per minute; extruder 269.36 grams per minute; and chopper = 4 mm chop length. Under these conditions, 13 Kg of  
10 conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 84.72 Kg of thermoplastic resin affording 99.67 Kg of composite pellets having the composition of 13.04 % copper fiber, 1.96% bis-A-diol / bisphenol-A chemical treatment, and 85% PC-ABS, with the chemically treated metallized fiber tow comprising 15%  
15 of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored but not well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 14db.

20 Example 28

Using the same chemical treatment as in Example 16, and carbon fiber of average yield 0.82 grams per meter, a sample containing a very low concentration of conductive fiber may be prepared by setting the process parameters as follows: puller = 30.48 meters per minute;  
25 Zenith pump = 6.3 grams per minute; extruder 1010.4 grams per minute; and chopper = 4 mm chop length. Under these conditions, 4.8 Kg of conductive fiber was coated with 1.2 Kg of chemical treatment and the mixture was then encapsulated with 194 Kg of thermoplastic resin affording 200 Kg of composite pellets having the composition of 2.4 % conductive fiber, 0.6 % bis-A-diol / bisphenol-A chemical treatment, and 97% PC-ABS, with the chemically treated  
30 carbon fiber tow comprising 3% of the finished composite compound. The pellets were of

uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 2mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 17db as measured by the ASTM D4935 and a surface resistivity of 600 - 7000 ohm/sq.

#### Example 29

Using the same chemical treatment as in Example 16, and carbon fiber of average yield 0.82 grams per meter, a sample containing a high concentration of conductive fiber may be prepared by setting the process parameters as follows: puller = 30.48 meters per minute; Zenith pump = 6.3 grams per minute; extruder 125 grams per minute; and chopper = 4 mm chop length. Under these conditions, 16 Kg of conductive fiber was coated with 4 Kg of chemical treatment and the mixture was then encapsulated with 80 Kg of thermoplastic resin affording 100 Kg of composite pellets having the composition of 16 % conductive fiber, 4 % bis-A-diol / bisphenol-A chemical treatment, and 80% PC-ABS, with the chemically treated carbon fiber tow comprising 20% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 2mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 56db as measured by the ASTM D4935 and a surface resistivity of 3 -8 ohm/sq.

#### Example 30 (Inventive Sample 15% Fiber)

A 4.38 molal solution was prepared by adding 1.5 Kg, 6.57 moles of bisphenol-A to 1.5 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was

maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 40 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 9.20 grams per minute; extruder 337.17 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was nickel plated carbon fiber with an average yield of 2.01 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 13 Kg of nickel coated carbon conductive fiber was coated with 1.95 Kg of chemical treatment and the mixture was then encapsulated with 71.47 Kg of thermoplastic resin affording 86.40 Kg of composite pellets having the composition of 15.04 % nickel coated carbon fiber, 2.26% bis-A-diol / bisphenol-A chemical treatment, and 82.7% PC-ABS, with the chemically treated metallized fiber tow comprising 17.3% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 80db as measured by the ASTM D4935 test and a surface resistivity of less than 3.1 ohm/sq.

#### Example 31 (Inventive Sample 10% Fiber)

A 4.38 molal solution was prepared by adding 1.5 Kg, 6.57 moles of bisphenol-A to 1.5 Kg of bisphenol-A-propoxylate in a one gallon metal paint can. This chemical treatment mixture was then heated in an oven at 130 °F (54.4 °C) for three hours. Once at thermal equilibrium, the container with the now homogeneous chemical treatment was placed on the hot plate of the process apparatus described in the above general section and the temperature was maintained at 120 °F (48.9 °C). At this temperature, the solution had a viscosity of 40 cps. The process parameters were set as follows: puller = 30.48 meters per minute; Zenith pump = 9.20 grams per minute; extruder 542.8 grams per minute; and chopper = 4 mm chop length. The conductive fiber used was nickel plated carbon fiber with an average yield of 2.01 grams per meter and was heated by passing it through the tube furnace. Under these conditions, 8.7 Kg of nickel coated carbon conductive fiber was coated with 1.31 Kg of chemical treatment and the mixture was then encapsulated with 77.0 Kg of thermoplastic resin affording 87.0 Kg

of composite pellets having the composition of 10.0 % nickel coated carbon fiber, 1.5% bis-A-diol / bisphenol-A chemical treatment, and 88.5% PC-ABS, with the chemically treated metallized fiber tow comprising 11.5% of the finished composite compound. The pellets were of uniform size and shape with the fiber bundle anchored and well centered in the thermoplastic sheath. The pellets were injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 60db as measured by the ASTM D4935 test and a surface resistivity of less than 3.1 ohm/sq.

#### Example 32 (Comparative Sample 15% Fiber)

The material used for this example is INCOSHIELD™ PMMA Long Fiber Nickel Concentrate available from Inco Special Products, 681 Lawlins Rd., Wyckoff, NJ 07481. Following the product literature instructions, 1.13 Kg of the long fiber nickel concentrate was mixed with 3.4 Kg of dried PC/ABS in Littleford Mixer model FM-130D, available from Littleford Bros., Inc. of Florence, KY 41042. The pellet mixture was injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a shielding effectiveness value of 64db as measured by the ASTM D4935 test and a surface resistivity of less than 21 ohm/sq.

#### Example 33 (Comparative Sample – 10% Fiber)

As above, the material used for this example is INCOSHIELD™ PMMA Long Fiber Nickel Concentrate available from Inco Special Products, 681 Lawlins Rd., Wyckoff, NJ 07481. Following the product literature instructions, 0.758 Kg of the long fiber nickel concentrate was mixed with 3.8 Kg of dried PC/ABS in Littleford Mixer model FM-130D, available from Littleford Bros., Inc. of Florence, KY 41042. The pellet mixture was injection molded at a melt temperature of 570 °F (299 °C) into a tool at 150 °F (65.5 °C). The resulting 4" (10.16 cm) diameter X 1mm disk test specimens had conductive fibers well dispersed throughout the composite. No undispersed bundles of fibers were observed. The composite exhibited a



shielding effectiveness value of 42db as measured by the ASTM D4935 test and a surface resistivity of less than 1000 ohm/sq.

- 5 While preferred embodiments have been shown and described herein, it should be understood that a number of changes and modifications are possible therein. Accordingly, it is to be understood that there is no intention to limit the invention to the precise construction disclosed herein, and the right is reserved to all changes and modifications coming within the scope of the invention as defined in the appended claims.

## CLAIMS:

1. A composite article comprising conductive fiber strands dispersed in a polymer matrix wherein said fibers have a chemical treatment coating comprising an organic material having a viscosity at a temperature range of 80 °C - 180 °C no greater than 1500 cps

5

2. The composite of claim 1 wherein the viscosity of the organic material at a temperature range of 80 °C - 180 °C is no greater than 800 cps.

10

3. The composite of claim 1 wherein the viscosity of the organic material at a temperature range of 80 °C - 180 °C is no greater than 400 cps.

4. The composite of claim 1 wherein the viscosity of the organic material at a temperature range of 80 °C - 180 °C is no greater than 200 cps.

15

5. The composite of claim 1 wherein the viscosity of the organic material at a temperature range of 80 °C - 180 °C is no greater than 75 cps.

6. The composite of claim 1 wherein the viscosity of the organic material at a temperature range of 80 °C - 180 °C is no greater than 25 cps.

20

7. The composite of claim 1 wherein the viscosity of the organic material at a temperature range of 80 °C - 180 °C is no greater than 5 cps.

25

8. The composite of claim 1 wherein the organic material comprises monomers or oligomers or mixtures thereof.

30

9. The composite of claim 1 wherein the organic material is chosen from the group consisting of bisphenol A, propoxylated bisphenol A, diphenyl ether, diphenyl sulfone, stilbene, diglycidyl ether of bisphenol A, triglycidylisocyanurate, citric acid, pentaerythritol, dicyandilimide, 4,4'-sulfonyle dianiline, 3,3'-sulfonyle dianiline, stearate-

capped propyleneglycol fumarate oligomer, butoxyethylstearate, ethylene carbonate, sorbitan monostearate, hydrogenated vegetable oil, and mixtures thereof.

10. The composite of claim 1 wherein the polymer matrix is a thermoset or thermoplastic polymer.

11. The composite of claim 1 wherein the polymer matrix is chosen from the group consisting of polycarbonate, acrylonitrile butadiene styrene, polycarbonate acrylonitrile butadiene styrene copolymer, polybutylene terephthalate, styrene, polypropylene, and nylon.

12. The composite of claim 1 wherein the conductive fiber strands comprise conductive fibers chosen from a group consisting of carbon fiber, metalized carbon fiber, metalized glass fiber, metal fiber, metal alloy fiber and mixtures thereof.

13. The composite of claim 1 wherein the strands have an average length of between 2mm to 12mm

14. The composite of claim 1 wherein the strands comprise bundles of at least 40 conductive fibers

15. A plurality of pellets capable of being consolidated into an electrically shielded composite wherein said pellets comprise a core of conductive fibers; wherein said core has a coating comprising an organic material having a viscosity at a temperature range of from 80 °C - 180 °C no greater than 1500 cps; and wherein said core and said coating are encased by a polymer.

16. The pellets of claim 15 wherein the pellets are capable of being consolidated into a composite without the addition of any other material.

17. The pellets of claim 15 wherein the pellets have an average length of between 2mm to 12mm
18. The pellets of claim 15 wherein the core is a strand comprising bundles of at least 40  
5       conductive fibers.
19. The pellets of claim 15 wherein the organic material has a viscosity at a temperature range of from 80 °C - 180 °C no greater than 400 cps.
- 10   20. The pellets of claim 15 wherein the organic material has a viscosity at a temperature range of from 80 °C - 180 °C no greater than 200 cps.
21. The pellets of claim 15 wherein the organic material has a viscosity at a temperature range of from 80 °C - 180 °C no greater than 75 cps.
- 15   22. The pellets of claim 15 wherein the organic material has a viscosity at a temperature range of from 80 °C - 180 °C no greater than 5 cps.
23. The pellets of claim 15 wherein the organic material comprises monomers or  
20       oligomers or mixtures thereof.
24. The pellets of claim 15 wherein the organic material is chosen from the group consisting of bisphenol A, propoxylated bisphenol A, diphenyl ether, diphenyl sulfone, stilbene, diglycidyl ether of bisphenol A, triglycidylisocyanurate, citric acid,  
25       pentaerythritol, dicyandilimide, 4,4'-sulfonyldianiline, 3,3'-sulfonyldianiline, stearate-capped propyleneglycol fumarate oligomer, butoxyethylstearate, ethylene carbonate, sorbitan monostearate, hydrogenated vegetable oil, and mixtures thereof
25. The pellets of claim 15 wherein the polymer is a thermoset or thermoplastic polymer.

26. The composite of claim 15 wherein the polymer is chosen from the group consisting of polycarbonate, acrylonitrile butadiene styrene, polycarbonate acrylonitrile butadiene styrene copolymer, polybutylene terephthalate, styrene, polypropylene, and nylon

5

27. The pellets of claim 15 wherein the core comprises chosen from the group consisting of carbon fiber, metalized carbon fiber, metalized glass fiber, metal fiber, metal alloy fiber and mixtures thereof.

10 28. A method for making pellets capable of being consolidated into an electromagnetic shielded composite comprising the steps of:

a) producing a chemically treated strand by coating conductive fibers with a chemical treatment comprising an organic material having a viscosity at a temperature of from 80 °C - 180 °C no greater than 1500 cps

15 b) producing a sheathed strand by encasing the chemically treated strand with a polymer

c) chopping the sheathed strand to form pellets

20 29. A method for making an electromagnetic shielded product by consolidating the pellets of claim 15.

30. A method for making an electromagnetic shielded product by consolidating the pellets of claim 28.

# ABSTRACT

The present invention relates to composites useful for shielding electromagnetic radiation and their manufacture. In general, the composites of the present invention comprise conductive fibers which are highly dispersed in a polymer matrix. The invention also relates to pellets and their manufacture. Such pellets are useful in the manufacture of composites comprising highly dispersed conductive fibers in a polymer matrix.

5

10

11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123  
124  
125  
126  
127  
128  
129  
130  
131  
132  
133  
134  
135  
136  
137  
138  
139  
140  
141  
142  
143  
144  
145  
146  
147  
148  
149  
150  
151  
152  
153  
154  
155  
156  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215  
216  
217  
218  
219  
220  
221  
222  
223  
224  
225  
226  
227  
228  
229  
230  
231  
232  
233  
234  
235  
236  
237  
238  
239  
240  
241  
242  
243  
244  
245  
246  
247  
248  
249  
250  
251  
252  
253  
254  
255  
256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268  
269  
270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329  
330  
331  
332  
333  
334  
335  
336  
337  
338  
339  
340  
341  
342  
343  
344  
345  
346  
347  
348  
349  
350  
351  
352  
353  
354  
355  
356  
357  
358  
359  
360  
361  
362  
363  
364  
365  
366  
367  
368  
369  
370  
371  
372  
373  
374  
375  
376  
377  
378  
379  
380  
381  
382  
383  
384  
385  
386  
387  
388  
389  
390  
391  
392  
393  
394  
395  
396  
397  
398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478  
479  
480  
481  
482  
483  
484  
485  
486  
487  
488  
489  
490  
491  
492  
493  
494  
495  
496  
497  
498  
499  
500  
501  
502  
503  
504  
505  
506  
507  
508  
509  
510  
511  
512  
513  
514  
515  
516  
517  
518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539  
540  
541  
542  
543  
544  
545  
546  
547  
548  
549  
550  
551  
552  
553  
554  
555  
556  
557  
558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609  
610  
611  
612  
613  
614  
615  
616  
617  
618  
619  
620  
621  
622  
623  
624  
625  
626  
627  
628  
629  
630  
631  
632  
633  
634  
635  
636  
637  
638  
639  
640  
641  
642  
643  
644  
645  
646  
647  
648  
649  
650  
651  
652  
653  
654  
655  
656  
657  
658  
659  
660  
661  
662  
663  
664  
665  
666  
667  
668  
669  
670  
671  
672  
673  
674  
675  
676  
677  
678  
679  
680  
681  
682  
683  
684  
685  
686  
687  
688  
689  
690  
691  
692  
693  
694  
695  
696  
697  
698  
699  
700  
701  
702  
703  
704  
705  
706  
707  
708  
709  
710  
711  
712  
713  
714  
715  
716  
717  
718  
719  
720  
721  
722  
723  
724  
725  
726  
727  
728  
729  
730  
731  
732  
733  
734  
735  
736  
737  
738  
739  
740  
741  
742  
743  
744  
745  
746  
747  
748  
749  
750  
751  
752  
753  
754  
755  
756  
757  
758  
759  
760  
761  
762  
763  
764  
765  
766  
767  
768  
769  
770  
771  
772  
773  
774  
775  
776  
777  
778  
779  
780  
781  
782  
783  
784  
785  
786  
787  
788  
789  
790  
791  
792  
793  
794  
795  
796  
797  
798  
799  
800  
801  
802  
803  
804  
805  
806  
807  
808  
809  
810  
811  
812  
813  
814  
815  
816  
817  
818  
819  
820  
821  
822  
823  
824  
825  
826  
827  
828  
829  
830  
831  
832  
833  
834  
835  
836  
837  
838  
839  
840  
841  
842  
843  
844  
845  
846  
847  
848  
849  
850  
851  
852  
853  
854  
855  
856  
857  
858  
859  
860  
861  
862  
863  
864  
865  
866  
867  
868  
869  
870  
871  
872  
873  
874  
875  
876  
877  
878  
879  
880  
881  
882  
883  
884  
885  
886  
887  
888  
889  
890  
891  
892  
893  
894  
895  
896  
897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932  
933  
934  
935  
936  
937  
938  
939  
940  
941  
942  
943  
944  
945  
946  
947  
948  
949  
950  
951  
952  
953  
954  
955  
956  
957  
958  
959  
960  
961  
962  
963  
964  
965  
966  
967  
968  
969  
970  
971  
972  
973  
974  
975  
976  
977  
978  
979  
980  
981  
982  
983  
984  
985  
986  
987  
988  
989  
990  
991  
992  
993  
994  
995  
996  
997  
998  
999  
1000  
1001  
1002  
1003  
1004  
1005  
1006  
1007  
1008  
1009  
1010  
1011  
1012  
1013  
1014  
1015  
1016  
1017  
1018  
1019  
1020  
1021  
1022  
1023  
1024  
1025  
1026  
1027  
1028  
1029  
1030  
1031  
1032  
1033  
1034  
1035  
1036  
1037  
1038  
1039  
1040  
1041  
1042  
1043  
1044  
1045  
1046  
1047  
1048  
1049  
1050  
1051  
1052  
1053  
1054  
1055  
1056  
1057  
1058  
1059  
1060  
1061  
1062  
1063  
1064  
1065  
1066  
1067  
1068  
1069  
1070  
1071  
1072  
1073  
1074  
1075  
1076  
1077  
1078  
1079  
1080  
1081  
1082  
1083  
1084  
1085  
1086  
1087  
1088  
1089  
1090  
1091  
1092  
1093  
1094  
1095  
1096  
1097  
1098  
1099  
1100  
1101  
1102  
1103  
1104  
1105  
1106  
1107  
1108  
1109  
1110  
1111  
1112  
1113  
1114  
1115  
1116  
1117  
1118  
1119  
1120  
1121  
1122  
1123  
1124  
1125  
1126  
1127  
1128  
1129  
1130  
1131  
1132  
1133  
1134  
1135  
1136  
1137  
1138  
1139  
1140  
1141  
1142  
1143  
1144  
1145  
1146  
1147  
1148  
1149  
1150  
1151  
1152  
1153  
1154  
1155  
1156  
1157  
1158  
1159  
1160  
1161  
1162  
1163  
1164  
1165  
1166  
1167  
1168  
1169  
1170  
1171  
1172  
1173  
1174  
1175  
1176  
1177  
1178  
1179  
1180  
1181  
1182  
1183  
1184  
1185  
1186  
1187  
1188  
1189  
1190  
1191  
1192  
1193  
1194  
1195  
1196  
1197  
1198  
1199  
1200  
1201  
1202  
1203  
1204  
1205  
1206  
1207  
1208  
1209  
1210  
1211  
1212  
1213  
1214  
1215  
1216  
1217  
1218  
1219  
1220  
1221  
1222  
1223  
1224  
1225  
1226  
1227  
1228  
1229  
1230  
1231  
1232  
1233  
1234  
1235  
1236  
1237  
1238  
1239  
1240  
1241  
1242  
1243  
1244  
1245  
1246  
1247  
1248  
1249  
1250  
1251  
1252  
1253  
1254  
1255  
1256  
1257  
1258  
1259  
1260  
1261  
1262  
1263  
1264  
1265  
1266  
1267  
1268  
1269  
1270  
1271  
1272  
1273  
1274  
1275  
1276  
1277  
1278  
1279  
1280  
1281  
1282  
1283  
1284  
1285  
1286  
1287  
1288  
1289  
1290  
1291  
1292  
1293  
1294  
1295  
1296  
1297  
1298  
1299  
1300  
1301  
1302  
1303  
1304  
1305  
1306  
1307  
1308  
1309  
1310  
1311  
1312  
1313  
1314  
1315  
1316  
1317  
1318  
1319  
1320  
1321  
1322  
1323  
1324  
1325  
1326  
1327  
1328  
1329  
1330  
1331  
1332  
1333  
1334  
1335  
1336  
1337  
1338  
1339  
1340  
1341  
1342  
1343  
1344  
1345  
1346  
1347  
1348  
1349  
1350  
1351  
1352  
1353  
1354  
1355  
1356  
1357  
1358  
1359  
1360  
1361  
1362  
1363  
1364  
1365  
1366  
1367  
1368  
1369  
1370  
1371  
1372  
1373  
1374  
1375  
1376  
1377  
1378  
1379  
1380  
1381  
1382  
1383  
1384  
1385  
1386  
1387  
1388  
1389  
1390  
1391  
1392  
1393  
1394  
1395  
1396  
1397  
1398  
1399  
1400  
1401  
1402  
1403  
1404  
1405  
1406  
1407  
1408  
1409  
1410  
1411  
1412  
1413  
1414  
1415  
1416  
1417  
1418  
1419  
1420  
1421  
1422  
1423  
1424  
1425  
1426  
1427  
1428  
1429  
1430  
1431  
1432  
1433  
1434  
1435  
1436  
1437  
1438  
1439  
1440  
1441  
1442  
1443  
1444  
1445  
1446  
1447  
1448  
1449  
1450  
1451  
1452  
1453  
1454  
1455  
1456  
1457  
1458  
1459  
1460  
1461  
1462  
1463  
1464  
1465  
1466  
1467  
1468  
1469  
1470  
1471  
1472  
1473  
1474  
1475  
1476  
1477  
1478  
1479  
1480  
1481  
1482  
1483  
1484  
1485  
1486  
1487  
1488  
1489  
1490  
1491  
1492  
1493  
1494  
1495  
1496  
1497  
1498  
1499  
1500  
1501  
1502  
1503  
1504  
1505  
1506  
1507  
1508  
1509  
1510  
1511  
1512  
1513  
1514  
1515  
1516  
1517  
1518  
1519  
1520  
1521  
1522  
1523  
1524  
1525  
1526  
1527  
1528  
1529  
1530  
1531  
1532  
1533  
1534  
1535  
1536  
1537  
1538  
1539  
1540  
1541  
1542  
1543  
1544  
1545  
1546  
1547  
1548  
1549  
1550  
1551  
1552  
1553  
1554  
1555  
1556  
1557  
1558  
1559  
1560  
1561  
1562  
1563  
1564  
1565  
1566  
1567  
1568  
1569  
1570  
1571  
1572  
1573  
1574  
1575  
1576  
1577  
1578  
1579  
1580  
1581  
1582  
1583  
1584  
1585  
1586  
1587  
1588  
1589  
1590  
1591  
1592  
1593  
1594  
1595  
1596  
1597  
1598  
1599  
1600  
1601  
1602  
1603  
1604  
1605  
1606  
1607  
1608  
1609  
1610  
1611  
1612  
1613  
1614  
1615  
1616  
1617  
1618  
1619  
1620  
1621  
1622  
1623  
1624  
1625  
1626  
1627  
1628  
1629  
1630  
1631  
1632  
1633  
1634  
1635  
1636  
1637  
1638  
1639  
1640  
1641  
1642  
1643  
1644  
1645  
1646  
1647  
1648  
1649  
1650  
1651  
1652  
1653  
1654  
1655  
1656  
1657  
1658  
1659  
1660  
1661  
1662  
1663  
1664  
1665  
1666  
1667  
1668  
1669  
1670  
1671  
1672  
1673  
1674  
1675  
1676  
1677  
1678  
1679  
1680  
1681  
1682  
1683  
1684  
1685  
1686  
1687  
1688  
1689  
1690  
1691  
1692  
1693  
1694  
1695  
1696  
1697  
1698  
1699  
1700  
1701  
1702  
1703  
1704  
1705  
1706  
1707  
1708  
1709  
1710  
1711  
1712  
1713  
1714  
1715  
1716  
1717  
1718  
1719  
1720  
1721  
1722  
1723  
1724  
1725  
1726  
1727  
1728  
1729  
1730  
1731  
1732  
1733  
1734  
1735  
1736  
1737  
1738  
1739  
1740  
1741  
1742  
1743  
1744  
1745  
1746  
1747  
1748  
1749  
1750  
1751  
1752  
1753  
1754  
1755  
1756  
1757  
1758  
1759  
1760  
1761  
1762  
1763  
1764  
1765  
1766  
1767  
1768  
1769  
1770  
1771  
1772  
1773  
1774  
1775  
1776  
1777  
1778  
1779  
1780  
1781  
1782  
1783  
1784  
1785  
1786  
1787  
1788  
1789  
1790  
1791  
1792  
1793  
1794  
1795  
1796  
1797  
1798  
1799  
1800  
1801  
1802  
1803  
1804  
1805  
1806  
1807  
1808  
1809  
1810  
1811  
1812  
1813  
1814  
1815  
1816  
1817  
1818  
1819  
1820  
1821  
1822  
1823  
1824  
1825  
1826  
1827  
1828  
1829  
1830  
1831  
1832  
1833  
1834  
1835  
1836  
1837  
1838  
1839  
1840  
1841  
1842  
1843  
1844  
1845  
1846  
1847  
1848  
1849  
1850  
1851  
1852  
1853  
1854  
1855  
1856  
1857  
1858  
1859  
1860  
1861  
1862  
1863  
1864  
1865  
1866  
1867  
1868  
1869  
1870  
1871  
1872  
1873  
1874  
1875  
1876  
1877  
1878  
1879  
1880  
1881  
1882  
1883  
1884  
1885  
1886  
1887  
1888  
1889  
1890  
1891  
1892  
1893  
1894  
1895  
1896  
1897  
1898  
1899  
1900  
1901  
1902  
1903  
1904  
1905  
1906  
1907  
1908  
1909  
1910  
1911  
1912  
1913  
1914  
1915  
1916  
1917  
1918  
1919  
1920  
1921  
1922  
1923  
1924  
1925  
1926  
1927  
1928  
1929  
1930  
1931  
1932  
1933  
1934  
1935  
1936  
1937  
1938  
1939  
1940  
1941  
1942  
1943  
1944  
1945  
1946  
1947  
1948  
1949  
1950  
1951  
1952  
1953  
1954  
1955  
1956  
1957  
1958  
1959  
1960  
1961  
1962  
1963  
1964  
1965  
1966  
1967  
1968  
1969  
1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015  
2016  
2017  
2018  
2019  
2020  
2021  
2022  
2023  
2024  
2025  
2026  
2027  
2028  
2029  
2030  
2031  
2032  
2033  
2034  
2035  
2036  
2037  
2038  
2039  
2040  
2041  
2042  
2043  
2044  
2045  
2046  
2047  
2048  
2049  
2050  
2051  
2052  
2053  
2054  
2055  
2056  
2057  
2058  
2059  
2060  
2061  
2062  
2063  
2064  
2065  
2066  
2067  
2068  
2069  
2070  
2071  
2072  
2073  
2074  
2075  
2076  
2077  
2078  
2079  
2080  
2081  
2082  
2083  
2084  
2085  
2086  
2087  
2088  
2089  
2090  
2091  
2092  
2093  
2094  
2095  
2096  
2097  
2098  
2099  
2100  
2101  
2102  
2103  
2104  
2105  
2106  
2107  
2108  
2109  
2110  
2111  
2112  
2113  
2114  
2115  
2116  
2117  
2118  
2119  
2120  
2121  
2122  
2123  
2124  
2125  
2126  
2127  
2128  
2129  
2130  
2131  
2132  
2133  
2134  
2135  
2136  
2137  
2138  
2139  
2140  
2141  
2142  
2143  
2144  
2145  
2146  
2147  
2148  
2149  
2150  
2151  
2152  
2153  
2154  
2155  
2156  
2157  
2158  
2159  
2160  
2161  
2162  
2163  
2164  
2165  
2166  
2167  
2168  
2169  
2170  
2171  
2172  
2173  
2174  
2175  
2176  
2177  
2178  
2179  
2180  
2181  
2182  
2183  
2184  
2185  
2186  
2187  
2188  
2189  
2190  
2191  
2192  
2193  
2194  
2195  
2196  
2197  
2198  
2199  
2200  
2201  
2202  
2203  
2

FIGURE 1

